may be necessary to change patterns if the measured resolution is outside the range of the initially selected pattern. Verify whether the proponent system transmits side panels that must be evaluated separately from the center image area. Also determine, from data supplied by the proponent, the number of frames necessary to capture photographically all of the chrominance information.

1.3.14.2 Measurement Technique

The technique for making these measurements is identical to that described in Section 1.3.2.2 for Luminance Static Vertical Resolution - ATV System.

1.3.14.3 Presentation of Data

The following data should be recorded for each set of measurements, Red and Blue:

From the picture monitor, the limiting vertical resolution of the center area, and of the side panels, in C/PH.

Photograph the picture monitor, using the video gate time specified by the proponent.

Make a 15-second recording on the HD DVTR, for each position of the test pattern at which a measurement is taken, and note the SMPTE time code at the start of each recording.

1.3.15 Chrominance Static Diagonal Resolution - ATV System

1.3.15.1 Setup

Two setups are required for measuring this parameter, and the complete procedure must be executed twice -- once for each setup. These setups are identical to those described in Section 1.3.13.1, except that the waveform monitor is not used but may remain connected.

Choosing among PIXAR Test Patterns 1, 2, and 3, as described in Section 1.3.13.1, select the appropriate pattern for each measurement, based upon the diagonal resolution claimed by the proponent. During the procedure, it may be necessary to change patterns if the measured resolution is outside the range of the initially selected pattern. Verify whether the proponent system transmits side panels that must be evaluated separately from the center image area. Also determine, from data supplied by the proponent, the number of frames necessary to capture photographically all of the chrominance information.

1.3.15.2 Measurement Technique

The technique for making these measurements is identical to that described in Section 1.3.3.2 for Luminance Static Diagonal Resolution - ATV System.

1.3.15.3 Presentation of Data

The following data should be recorded for each set of measurements, Red and Blue:

From the picture monitor, the limiting diagonal resolution of the center area, and of the side panels, in C/PH.

Photograph the picture monitor, using the video gate time specified by the proponent.

Make a 15-second recording on the HD DVTR, for each position of the test pattern at which a measurement is taken, and note the SMPTE time code at the start of each recording.

1.3.16 Chrominance Static Horizontal Resolution - NTSC Receiver Output

1.3.16.1 Setup

Two source setups are required for measuring this parameter, and the complete procedure must be executed twice -- once for each setup.

For all measurements, connect the Red, Green, and Blue outputs of the PIXAR to the respective inputs of the SUT.

For the first set of measurements, connect the Red output of the SUT to the waveform monitor. Terminate the cable in 75 ohms. Using matrix coefficients supplied by the proponent, set the amplitudes of the PIXAR outputs such that only the "R-Y" (or "I") color-difference channel of the SUT is modulated with an AC waveform, and the "B-Y" (or "Q") and luminance channels have a constant-amplitude signal over the entire area of the test pattern.

For the second set of measurements, connect the Blue output of the SUT to the waveform monitor. Terminate the cable in 75 ohms. Using matrix coefficients supplied by the proponent, set the amplitudes of the PIXAR outputs such that only the "B-Y" (or "Q") color-difference channel of the SUT is modulated with an AC waveform, and the "R-Y" (or "I") and luminance channels have a constant-amplitude signal over the entire area of the test pattern.

The monitors used for all of these measurements should employ comb filters, rather than band-pass filters, for separation of the chrominance signal with maximum bandwidth. Connect output of the reference NTSC demodulator to the waveform monitor. Connect the "picture monitor output" of the waveform monitor to the picture monitor.

Terminate all cables in 75 ohms.

Select PIXAR Test Pattern No. 3. It contains a radial resolution pattern, calibrated from 10 to 50 C/PH, in the NTSC compatible image area.

1.3.16.2 Measurement Technique

The technique for making this measurement is similar to that described in Section 1.3.4.2 for Luminance Static Horizontal Resolution - NTSC Output. There are two essential differences. First, on the picture monitor, dot crawl must be ignored in assessing the resolution of the red and blue pattern images. One way of cancelling the visibility of dot crawl is to make the measurement from a photograph, taken with a two-frame exposure, rather than from the picture monitor directly. Second, the waveform monitor displays the envelope of the chrominance signal, so all measurements should be made with respect to the depth of modulation of the color subcarrier. This is done by measuring the maximum and minimum peak-to-peak amplitudes of the chrominance envelope. The depth of modulation is the difference of these two amplitudes, as a percentage of twice the average amplitude.

Observe the picture monitor, and discern the limiting horizontal resolution. Look up and down along a vertical axis through the center of the pattern, and note the points above and below the center at which the individual radials emerge from the background. It may be necessary to adjust the monitor contrast to raise the luminance level of the saturated-color pattern. When viewing the Blue pattern, use of the "Blue Only" mode of the picture monitor, if provided, will improve the visibility of the pattern. Using the calibration circles, estimate the spatial frequency, in C/PH, at which the radials become visible.

Using the line selector of the waveform monitor, move the cursor so that it is tangent to a point of limiting resolution noted above. The modulation of the chrominance envelope should diminish to nearly zero at the center of this line.

Note the maximum and minimum peak-to-peak amplitudes of the chrominance envelope for the radial resolution pattern on the selected line. The depth of modulation calculated from these amplitudes is the reference for the resolution response measurement.

Move the line selector toward the top or bottom of the pattern to find the line corresponding to the half-amplitude resolution response. At the center of the correct line, the depth of modulation should be one-half of the reference modulation noted above. Observe the position of the line-select cursor overlaid on the picture display. Using the calibration circles, estimate the spatial frequency, in C/PH, at which the cursor intersects the vertical center axis of the pattern.

1.3.16.3 Presentation of Data

The following data should be recorded for each set of measurements, Red and Blue:

From the picture monitor, the limiting horizontal resolution in C/PH.

From the waveform monitor, the half-amplitude resolution response in C/PH.

For reference purposes, record the selected line numbers on which the limiting resolution, reference amplitude, and half amplitude were observed on the waveform monitor.

Photograph the picture monitor, using a video gate time of one frame. Also photograph the waveform monitor displays of the selected lines.

Make a 15-second recording on the NTSC DVTR, and note the SMPTE time code at the start of the recording.

1.3.17 Chrominance Static Vertical Resolution - NTSC Receiver Output

1.3.17.1 Setup

Two setups are required for measuring this parameter, and the complete procedure must be executed twice -- once for each setup. The source setups are identical to those described above, in Section 1.3.16.1. The monitoring differs in that comb filtering must not be used in this procedure. The picture monitor must employ band-pass filtering for separation of the chrominance signal. A waveform monitor is not used but may remain connected.

Select PIXAR Test Pattern No. 2. It contains a radial resolution pattern, calibrated from 50 to 250 C/PH, in the NTSC compatible image area.

1.3.17.2 Measurement Technique

Observe the picture monitor, and discern the limiting vertical resolution. Look side to side along a horizontal axis through the center of the pattern, and note the points left and right of the center at which the individual radials emerge from the background. It may be necessary to adjust the monitor contrast to raise the luminance level of the saturated-color pattern. When viewing the Blue pattern, use of the "Blue Only" mode of the picture monitor, if provided, will improve the visibility of the pattern. Using the calibration circles, estimate the spatial frequency, in C/PH, at which the radials become visible.

Spurious patterns, or aliasing, may be observed due to beats between the scanning lines and the test pattern. If aliasing obscures the point of limiting resolution, then the point at which the true pattern and the spurious pattern have equal contrast should be taken as the true resolution.

1.3.17.3 Presentation of Data

The following data should be recorded for each set of measurements, Red and Blue:

From the picture monitor, the limiting vertical resolution in C/PH.

Photograph the picture monitor using a video gate time of two frames.

Make a 15-second recording on the NTSC DVTR, and note the SMPTE time code at the start of the recording.

1.3.18 Chrominance Static Diagonal Resolution - NTSC Receiver Output

1.3.18.1 Setup

Two setups are required for measuring this parameter, and the complete procedure must be executed twice -- once for each setup. The source setups are identical to those described in Section 1.3.16.1. The monitoring differs in that comb filtering must not be used in this procedure. The picture monitor must employ band-pass filtering for separation of the chrominance signal. A waveform monitor is not used but may remain connected.

Select PIXAR Test Pattern No. 2. It contains a radial resolution pattern, calibrated from 50 to 250 C/PH, in the NTSC compatible image area.

1.3.18.2 Measurement Technique

Observe the picture monitor, and discern the limiting diagonal resolution. Look in the four corner quadrants of the pattern, and note the points at which the individual diagonal radials emerge from the background. The points of limiting resolution may not lie along 45-degree diagonals, but should be found symmetrically positioned with respect to the horizontal and vertical axes through the center of the pattern. It may be necessary to adjust the monitor contrast to raise the luminance level of the saturated-color pattern. When viewing the Blue pattern, use of the "Blue Only" mode of the picture monitor, if provided, will improve the visibility of the pattern. Using the calibration circles, estimate the spatial frequency, in C/PH, at which the radials become visible. Use the lowest frequency, at which limiting resolution is observed diagonally, as the true diagonal resolution.

1.3.18.3 Presentation of Data

The following data should be recorded for each set of measurements, Red and Blue:

From the picture monitor, the limiting diagonal resolution in C/PH.

If picture monitor photographs and NTSC DVTR recordings were obtained in the procedure of Section 1.3.17, above, this documentation need not be duplicated.

1.3.19 Chrominance Dynamic Horizontal Resolution - ATV System

The previously released dynamic resolution measurement procedure has been withdrawn. (See Section 1.3.7.) An alternative procedure is under study.

1.3.20 Chrominance Dynamic Vertical Resolution - ATV System

The previously released dynamic resolution measurement procedure has been withdrawn. See Section 1.3.7.) An alternative procedure is under study.

1.3.21 Chrominance Dynamic Diagonal Resolution - ATV System

The previously released dynamic resolution measurement procedure has been withdrawn. (See Section 1.3.7.) An alternative procedure is under study.

1.3.22 Chrominance Dynamic Horizontal Resolution - NTSC Receiver Output

The previously released dynamic resolution measurement procedure has been withdrawn. (See Section 1.3.7.) An alternative procedure is under study.

1.3.23 Chrominance Dynamic Vertical Resolution - NTSC Receiver Output

The previously released dynamic resolution measurement procedure has been withdrawn. (See Section 1.3.7.) An alternative procedure is under study.

1.3.24 Chrominance Dynamic Diagonal Resolution - NTSC Receiver Output

The previously released dynamic resolution measurement procedure has been withdrawn. (See Section 1.3.7.) An alternative procedure is under study.

2. Three-Dimensional Time-Domain Signature

In the previously released revision of this document, dated September 14, 1989, this section was entitled, "Three-Dimensional Frequency Response." The procedures employ techniques conventionally applied to linear, time-invariant systems. Many of the proponent ATV systems currently scheduled for testing by ATTC violate the assumptions of these measurement techniques. These systems may employ artificial improvement of transient response, adaptive processing, or time-varying filters. Since the procedures cannot be applied universally for measurement of 3-D frequency response, they have been withdrawn for this purpose. However, the secondary application for the procedures -- generation of signatures or "fingerprints" of system performance -- will be exploited randomly by ATTC to detect any changes in system performance during the testing period. There will be no other use of the data.

As in the previous version of this document, the introductory material in this section applies also to the Transient Response section, which follows.

2.1 Introduction

Broadcast television systems typically are tested by the well-known Pulse and Bar techniques documented in ANSI/IEEE Standard 511-1979, Standard on Video Signal Transmission, Measurement of Linear Waveform Distortion. Such testing is considered superior to frequency domain testing, as the effects of unequal delay for all frequency components produce severe picture impairments not measured with the usual frequency domain tests, such as multiburst or swept frequency. Existing broadcast systems do not employ vertical or temporal filters, but only low-pass (horizontal) filters. Therefore, only horizontal frequency response need be measured and is, in fact, measured by the present testing techniques. However, ATV systems do employ vertical-temporal filters, the effects of which must be measured. In effect, the one-dimensional measurement is expanded to a three-dimensional problem for ATV systems.

2.1.1 Definitions

Sine-squared Pulse describes the shape of the test signal that is generally used to measure the linear waveform distortion of a transmission system. The shape of the signal is equivalent to a single cycle of a sine wave from one negative peak to the next.

HAD, or Half-Amplitude Duration, is the period between the 50-percent amplitude points of the pulse.

T is the period corresponding to one half cycle of a sine wave at the nominal cut-off frequency of the transmission system. For CCIR System M, T = 125 nanoseconds, which corresponds to a frequency of 4 MHz.

These three definitions are related in that virtually all of the spectral energy of a sine-squared pulse, having an HAD of 2T, is contained within the pass band of the transmission system for which T has been defined. Also, the distribution of this energy is generally similar to that expected from normal picture content.

In the development of HDTV systems, it has become conventional practice to retain the CCIR System M value for T. The HAD of the test signal is scaled to the appropriate fraction of T necessary to maintain the above-described relationship between the spectral energy of the signal and the pass band of the system. For a 30-MHz HDTV production system, a period of T/8 has the same relationship as a period of T for System M.

2.1.2 General Description of Method

The basic time-domain method is patterned after ANSI/IEEE 511. A T/4 pulse and bar waveform is transmitted through the system under test (SUT). The HAD of the pulse is T/4. The 10-90-percent rise and fall times of the bar are T/8. The bar is used as the amplitude reference, and one principal measurement is the Pulse-to-Bar amplitude ratio (P/B Ratio) at the system output. Losses in high video frequencies lower the pulse amplitude, relative to the bar, and increase the pulse width (HAD). The resulting HAD is the second principal measurement. Group envelope delay causes the output pulse and the bar transitions to become asymmetric. Evaluation of these transition distortions is beyond the scope of this frequency-response measurement procedure, but it is covered in detail in Section 3, Transient Response.

The method may be expanded to vertical-domain measurement by using the pulse and window form of the basic test signal. A vertical filter in the system under test will cause the peak amplitude of the window to vary line by line. These variations may be explored using the Line Select function of the waveform monitor.

Extension of this measurement concept to the temporal domain requires that the test signal be gated onto, for example, one field out of eight consecutive frames. Any temporal filter in the system under test will redistribute some of the energy in the T/4 pulse into other fields, lowering the amplitude of the pulse in these fields. Such a filter will also cause reduced-amplitude bars or windows to appear in the adjacent fields.

Additional test signals may be used, at the discretion of ATTC, in order to generate three-dimensional "fingerprints" of system performance. This fingerprint testing may be repeated over the term of residency of each proponent to determine quickly whether any change in performance of his system has occurred.

Only the luminance response of the ATV system, end to end, shall be measured in this procedure. The test signal shall be applied equally to the Red, Green, and Blue inputs of the system under test. It shall be assumed that the performance observed at the Green output is representative of the luminance performance, and only this output shall be measured.

2.2 Test and Measuring Equipment

2.2.1 Signal Sources

2.2.1.1 Test Pattern

The T/4 pulse and window waveforms required for this procedure are generated by the PIXAR. Due to the similarity between these waveforms and those required for the Transient Response measurements, that are covered in Section 3, a single pattern is used. The frequency response test signals comprise a subset of the waveforms on this pattern.

2.2.1.2 Active Video Gate

Temporal response measurement requires that the test signal be gated onto certain fields only, so that the effect of temporal filtering in the SUT may be observed on the intervening fields. This gating is accomplished by interposing an Active Video Gate between the PIXAR and the SUT. An appropriate device could be the same one described in Section 1.2.2.1, with the addition of a free-run mode to provide a 1-of-N duty cycle for the fields that are passed. A 1-field-out-of-8-frame duty cycle is both sufficient and simple to implement. It must be possible to select either odd or even fields to be passed.

2.2.2 Monitoring

The waveform monitor shall have a vertical amplifier bandwidth and transient response such as to introduce negligible display errors at any frequency up to at least 30 MHz. It shall be fitted with a line selector, which will permit the selection, display, and identification of any desired single horizontal scan interval, or series of consecutive horizontal scan intervals (typically 14), once each frame time. It shall provide calibrated time-base and amplitude magnification of any portion of the horizontal scan interval.

The picture monitor is noncritical for this procedure. It is used as a continuity monitor and for identification of those portions of the test pattern selected for display on the waveform monitor.

2.3 Procedure

2.3.1 Setup

Connect the output of the PIXAR to the Red, Green, and Blue inputs of the SUT, through an active video gate as described above in Section 1.2.1.2. Use a wideband video distribution amplifier driving equal lengths of identical coaxial cable into 75-ohm terminations at the encoder input.

Connect the Green output of the SUT to the waveform monitor. Connect the "picture monitor output" of the waveform monitor to the picture monitor. Terminate each cable in 75 ohms.

Select PIXAR test pattern No. __. Among the waveforms on this pattern are a T/4 sine-squared pulse, having an HAD of 31.25 nanoseconds, and a window, having 10-90-percent rise and fall times of T/8, or 15.625 nanoseconds. The horizontal window transitions have integrated sine-squared shaping. The peak amplitude of these signals is 700 millivolts above the blanking level baseline.

2.3.2 Measurement Technique

2.3.2.1 Horizontal Frequency Response

Select for viewing a line containing a T/4 pulse. Magnify the waveform display time base, so that the shape of the pulse and any distortion may be discerned. Measure the peak amplitude of the pulse, ignoring any distortion near the baseline. Also measure the HAD, the time between the 50-percent amplitude points.

Next, select for viewing a line through the center of the window. Measure the peak amplitude of the waveform, at the middle of the window horizontally, with respect to the blanking level baseline.

Pan the PIXAR test pattern horizontally so that the T/4 pulse is located within the side panel area, six percent of the active line time after the start of active video. Measure the peak amplitude and the HAD of the pulse, using the technique described in the first paragraph, above.

Pan the PIXAR test pattern so that the window is centered horizontally within the side panel area. Measure the peak amplitude, using the technique described above, in the second paragraph.

Return the PIXAR pattern to the centered position.

2.3.2.2 Vertical Frequency Response

Move the Line Select cursor vertically to display the waveform of the first line on which the window appears at full amplitude. Measure the peak amplitude of the waveform, with respect to the blanking level baseline, at the horizontal midpoint of the window.

Move the cursor up one line. If a diminished amplitude window appears on this line, then the SUT contains a vertical filter. Measure the peak amplitude of this waveform as before.

Continue moving the cursor up, one line at a time, and look for a diminished amplitude window on each line, until no vestige of the window waveform can be seen. Measure the amplitude on each line and note which line is being viewed.

Move the Line Select cursor down to display the waveform of the lowest line on which the window appears at full amplitude. Measure the peak amplitude on this line.

Continue moving the cursor down, one line at a time, and measure the amplitude of the waveform on each line where a vestige of the window appears. Note the line on which each measurement is taken.

Pan the PIXAR test pattern so that the window is centered horizontally within the side panel area. Then, repeat the complete procedure detailed in the five paragraphs above.

Return the PIXAR pattern to the centered position.

2.3.2.3 Temporal Frequency Response

Set the waveform monitor to display a series of consecutive lines (typically 14). Move the Line Select cursor such that the displayed lines are centered vertically within the window.

Enable the active video gate such that one field, out of eight consecutive frames, is passed through the SUT. For interlaced systems, execute the procedure twice--once using an odd field, and again using an even field.

Observe the displayed waveform, adjusting the brightness as necessary to compensate for the reduced duty cycle. In addition to the brightest trace, showing the waveform at full amplitude, there may be one or more dimmer traces, showing waveforms at diminished amplitudes. The dimmer traces are evidence of temporal filtering in the SUT. Note the number, and measure the amplitudes, of all separate traces observed.

Pan the PIXAR test pattern so that the window is centered horizontally within the side panel area. Then, repeat the procedure described in the preceding paragraph.

Return the PIXAR pattern to the centered position, and reset the active video gate to pass all lines.

2.3.3 Presentation of Data

The following data should be recorded for both the center area and the side panel area:

From the Horizontal Frequency Response measurement, the P/B Ratio, expressed as a percentage of the bar (window) amplitude, and the HAD of the T/4 pulse.

From the Vertical Frequency Response measurement, the line number and the window amplitude for all lines on which the window waveform was observed.

From the Temporal Frequency Response measurement, the amplitudes of all separate traces observed.

Photograph all of the waveform monitor displays from which data was taken. In photographing the temporal frequency response display, be sure to use an exposure time of at least eight frames.

Make four (or eight) separate, 15-second, recordings on the HD DVTR, and note the SMPTE time code at the start of each recording. The recordings should correspond to the following measurement conditions (for odd and even field, in the case of interlaced systems):

(1) H or V Frequency Response, Pattern centered.
(2) H or V Frequency Response, Pattern in side panel.
(3) Temporal Frequency Response, Pattern centered.
(4) Temporal Frequency Response, Pattern in side panel.

3. Transient Response

3.1 Introduction

The introductory material presented in Section 2, Three-Dimensional Time-Domain Signature, is useful background for the Transient Response measurements that follow. Some of the applications of pulse and bar techniques to the testing of ATV systems now should be familiar to the reader.

It was noted in Section 2 that group envelope delay causes the output pulse and the bar transitions to become asymmetric. The ANSI/IEEE Standard 511-1979 characterizes these distortions and describes measurement methods for television systems conforming to CCIR System M. The techniques involve weighting measurements of the amplitude and distance from the transition midpoint of any ringing, overshoots, or undershoots. A waveform-monitor graticule is described to permit rapid evaluation of short-time waveform distortion, or "SD." In the absence of this special graticule, the constituent parameters may be measured individually, and SD may be calculated from a nomograph included in an Appendix to the Standard. For reference purposes, Figure B8 of ANSI/IEEE Standard 511-1979 is reproduced here as Figure __.

3.1.1 Definitions

Transient Response is characterized by the time response of a system to specific changing inputs. Generally, this is a measure used for characterizing linear systems. Although ATV systems are not necessarily linear, the transient response for specific inputs still may be specified.

Step describes a signal that represents a sudden transition from one level to another level. A spatial step shall have the transition occur along a straight line at a given angle relative to horizontal. A temporal step shall be represented by a flat field that changes from one level to another between successive frames.

Pulse describes a signal that represents a sudden transition from one level to another level, followed by a transition back to the original level. The first transition shall occur along a straight line at a given angle relative to horizontal. The second transition shall occur along a line parallel to the first line. The distance between the two parallel lines shall be defined as the pulse width.

Normalized Units (Picture Heights) shall be used to express all measurements, so that ATV systems having different scanning standards and different aspect ratios may be compared directly. The reference unit of measure shall be the active picture height.

3.1.2 General Description of Method

In general, transient response is evaluated by transmitting pulse and step waveforms through the system under test and measuring specified characteristics of the resulting waveform distortion. For an NTSC system, the techniques of ANSI/IEEE 511-1979 are sufficient. Due to the complex nature of the signal processing employed in ATV systems, the evaluation should be expanded in scope to include horizontal and vertical spatial axes, as well as the temporal dimension. The feasibility of including the diagonal spatial axes in the evaluation is under study. The multi-dimensional aspects of transient response measurement parallel the considerations involved in resolution measurement, as discussed in Section 1. As with resolution measurement, transient response measurement requires separate consideration of luminance and chrominance. Both static and dynamic performance must be evaluated. Furthermore, since the method to be used is generally applied to linear systems, the measurements must be repeated over a range of amplitudes of the test signal, in order to account for any nonlinearities in the ATV system.

Most of the waveforms used for these tests are variations of the basic T/4 pulse and window waveforms employed for three-dimensional frequency response measurement in Section 2. The variations include pulse width (HAD), amplitude, and orientation (horizontal, vertical). Dynamic characteristics are measured by moving the waveforms along the desired axis, and controlling the exposure time of the monitor photography. Temporal response measurement utilizes a flat field signal, which is gated on or off field by field.

For the purpose of testing luminance performance, the test signal shall be applied equally to the Red, Green, and Blue inputs of the system under test. It shall be assumed that the performance observed at the Green output is representative of the luminance performance, and only this output shall be measured. Chrominance performance shall be tested by individually testing each of two color-difference channels. For NTSC-compatibility tests, the output of a professional, reference-quality NTSC demodulator shall be connected to the monitoring equipment, luminance and chrominance being extracted within that equipment as required.

3.2 Test and Measuring Equipment

3.2.1 Signal Sources

3.2.1.1 Test Pattern

The test signals used in this procedure are obtained from the PIXAR generator. Two patterns are required. The first contains an array of pulses and a window. The pulses include:

(1) Eight horizontal white pulses, from a black-level base line, having half-amplitude durations of 16T, 8T, 4T, 2T, T, T/2, T/4, and T/8.

(2) Eight horizontal black pulses, from a white-level (700-mV) base line, having half-amplitude durations of 16T, 8T, 4T, 2T, T, T/2, T/4, and T/8.

(3) Eight vertical white pulses and eight vertical black pulses. The line structure does not permit sine-squared shaping, and the pulses appear as white lines surrounded by black lines, or as black lines surrounded by white lines. The pulse durations, counted in lines, have approximately the same spatial dimensions with respect to the active picture area as the horizontal pulses specified above.

The window has a rise time of T, horizontally, and a line-to-line step between black and white levels vertically. The arrangement of the features of this test pattern is depicted in Figure _. The peak-to-peak amplitude of all features is 700 mV.

The second test pattern is a flat white field of 700-mV amplitude.

The amplitudes of the Red, Green, and Blue output signals from the PIXAR may be adjusted individually such that only the luminance or one of the color-difference channels of the system under test is presented with the transient waveform. The proponent must supply the matrix coefficients for his system to permit this adjustment.

3.2.1.2 Attenuator

The output of the PIXAR shall be applied to an attenuator having steps of 0 dB, 3 dB, 6 dB, and 12 dB. This arrangement will provide test signal amplitudes of 700 mV, 495 mV, 350 mV, and 175 mV to the SUT.

3.2.1.3 Active Video Gate

Temporal response measurement requires that the test signal be gated onto certain fields only. A temporal step may be generated by passing the test signal for a certain number of fields, and then inhibiting it for a number of fields or frames. Since some ATV systems transmit chrominance information at a slower rate than luminance, the on and off durations of the test signal must be sufficient to permit measurement of the temporal transient response of the chrominance channels. The ratio of chrominance to luminance transmission rate may be as low as one-eighth.

The required gating may be accomplished by interposing an active video gate between the PIXAR and the SUT. An appropriate device could be the one described in Section 2.2.1.2, used for three-dimensional frequency response measurement, but modified to function with an M-of-N duty cycle. A 16-of-32 duty cycle may be required for this procedure. The active video gate must provide a logic-level output, corresponding to the "on" or "off" condition of the video, to be used to trigger other test equipment.

3.2.2 Monitoring

3.2.2.1 Active Video Gate

An active video gate, as described in Section 1.2.2.1, is required for monitor photography.

3.2.2.2 ATV Monitoring

The basic monitoring requirements are the same as those described in Section 2.2.2 for Three-Dimensional Frequency Response measurement. It is recommended that the waveform monitor feature numerical on-screen readout of time and amplitude.

An additional requirement for temporal response measurement is a slow horizontal sweep rate for the waveform display. Several consecutive frames, perhaps eight, must be observed. A separate oscilloscope may be used, with the waveform monitor serving as the signal-acquisition device for clamping purposes.

3.2.2.3 NTSC Monitoring

For those systems claiming NTSC compatibility, the compatible RF signal will be applied to a professional, reference-quality NTSC demodulator. Measurements will be made on the baseband NTSC video output from the demodulator.

A choice of two types of chrominance filtering must be available in the waveform monitor. This may require the use of two instruments. For horizontal measurements, a comb filter is required for the widest possible horizontal bandwidth. For vertical measurements, a band-pass filter must be used to avoid comb-filter artifacts.

The NTSC color picture monitor must not employ a comb filter for chrominance separation. A "blue only" mode will aid in observation of the low-luminance signal that results when only the Blue input of the SUT is excited.

Some of the measurement procedures rely upon analysis of photographed waveforms. Use of a video measurement instrument that features digital waveform storage, with a "freeze" function, and hard-copy output of the display, will simplify these procedures.

3.3 Procedures

3.3.1 Luminance Response to Stationary Step

3.3.1.1 Setup

Connect the output of the PIXAR, through the attenuator, to the Red, Green, and Blue inputs of the SUT. Use a wideband video distribution amplifier driving equal lengths of identical coaxial cable into 75-ohm terminations at the encoder input.

Connect the Green output of the SUT to the ATV waveform monitor. Connect the "picture monitor output" of this waveform monitor to the ATV picture monitor. Terminate each cable in 75 ohms.

Connect the output of the reference NTSC demodulator to the NTSC waveform monitor. Connect the "picture monitor output" of this waveform monitor to the NTSC picture monitor. Terminate each cable in 75 ohms.

Select PIXAR test pattern No. __. This pattern contains an array of pulses and windows of different widths and orientations. The peak amplitude of these signals is 700 mV above the blanking-level base line.

3.3.1.2 Measurement Technique

Each of the measurements below must be taken from both the Green output of the SUT, using the ATV monitors, and the NTSC demodulator output, using the NTSC monitors.

3.3.1.2.1 Horizontal Transient Response

Select for viewing a window signal having a rise time of T/8. Position the Line Select cursor at the vertical midpoint of the window.

Adjust the horizontal position and time-base expansion controls of the waveform monitor to magnify the positive-going edge of the window.

Set the attenuator at the 0-dB position.

Measure the following parameters:

(1) The 10-90-percent rise time.
(2) For any ringing that is observed, the time intervals between the half-amplitude point of the transition and the first two minimums and maximums. Also measure the amplitudes of these minimum and maximum points, as percentages of the steady-state window amplitude.
(3) The peak amplitude of any overshoot, as a percentage of the steady-state amplitude, and the time interval from the half-amplitude point of the transition to the peak.
(4) In the case of undershoot, the amplitude, as a percentage of the steady-state window amplitude, at a time interval equal to T after the half-amplitude point of the transition.

Repeat these measurements at 3-dB, 6-dB, and 12-dB attenuation.

Adjust the horizontal position control of the waveform monitor to display the negative-going edge of the window.

Measure Parameters 1 through 4 at attenuator settings of 0-dB, 3-dB, 6-dB, and 12-dB.

3.3.1.2.2 Vertical Transient Response

Set the attenuator at the 0-dB position.

Adjust the Line Selector to the vertical midpoint of the window. Observe the peak amplitude, with respect to the blanking-level base line, at the horizontal midpoint of the waveform. This is the steady-state reference amplitude.

Move the Line Selector up to the first line on which the window appears at reference amplitude. Then, move the cursor up and down over several lines to explore any transient levels between the blanking level above the window and the steady-state window amplitude. Measure the amplitudes of any observed transient levels, and note the lines on which they occur.

Next, move the Line Selector down to the lowest line on which the window appears at reference amplitude. Explore the surrounding lines for transient levels. Measure the amplitudes of any observed transient levels, and note the lines on which they occur.

Repeat this procedure for attenuator settings of 3-dB, 6-dB, and 12-dB.

3.3.1.3 Presentation of Data

In order to compare data among different ATV systems, the measurements taken above must be converted into normalized units of percentages of picture height. For vertical dimensions, counted in lines, divide the number of measured lines by the number of active lines specified by the proponent, and express the result as a percentage. For horizontal dimensions, measured in microseconds, divide the measurement by the length of the active line specified by the proponent, multiply by the aspect ratio, and express the result as a percentage.

Record, in normalized units, all of the parameter values obtained in the above procedures for horizontal and vertical transient response, at all four attenuator settings, for both the ATV and NTSC receiver outputs.

Photograph all of the waveform monitor displays from which data were taken.

Make a 30-second recording on each DVTR, HD and NTSC, at each of the four attenuator settings, and note the SMPTE time code at the start of each recording.

3.3.2 Luminance Response to Stationary Pulse

3.3.2.1 Setup

This procedure uses the same setup as described above in Section 3.3.1.1.

3.3.2.2 Measurement Technique

Each of the measurements below must be taken from both the Green output of the SUT, using the ATV monitors, and the NTSC demodulator output, using the NTSC monitors.

3.3.2.2.1 Horizontal Transient Response

Set the attenuator at the 0-dB position.

Move the Line Selector to the vertical midpoint of the window. Observe the peak amplitude, above the blanking-level base line, at the horizontal midpoint of the waveform. This is the reference amplitude for measuring the white pulse amplitudes.

Select for display the middle line of the several consecutive lines that contain the widest horizontal white pulse. Observe the peak amplitude of this pulse, relative to the blanking-level base line.

Then, select the middle line containing the next narrower white pulse, and observe the pulse amplitude. Continue until a pulse is found that has an amplitude of one half or less that of the reference.

Measure the amplitude of the pulse found above, and that of the next wider pulse. Assume that the system is linear in the vicinity of the half-amplitude level and estimate, by linear interpolation, the pulse width that would be reproduced at half the amplitude of the reference.

Move the Line Selector to the middle line containing the widest horizontal black pulse. Observe the amplitude of this pulse, negative-going from the white reference level.

Then, select the middle line containing the next narrower black pulse, and observe the pulse amplitude. Continue until a pulse is found that has a peak amplitude, measured downward from the white reference level, of no more than half of the amplitude of the white reference above blanking level.

Measure the amplitudes of both the black pulse found above and of the next wider black pulse, so that the pulse width that would be reproduced at half level may be estimated.

Repeat this entire procedure for attenuator settings of 3-dB, 6-dB, and 12-dB.

3.3.2.2.2 Vertical Transient Response

Set the attenuator at the 0-dB position.

Move the Line Selector to the vertical midpoint of the window. Observe the peak amplitude, above the blanking-level base line, at the horizontal midpoint of the waveform. This is the reference amplitude for measuring the white pulse amplitudes.

Select for display the line through the center of the widest vertical white pulse. Use the horizontal position and time-base expansion controls of the waveform monitor to display the horizontal midpoint of this pulse for easy measurement of the amplitude.

Compare the peak amplitude, with respect to blanking level, of the waveform on this line to that on adjacent lines, in order to ensure that the peak amplitude of the vertical white pulse is being observed.

Select the next narrower vertical white pulse, and observe the peak amplitude in the same manner. Continue until a pulse is found that has a peak amplitude of one half or less that of the reference.

Measure the peak amplitude of the pulse found above. Also measure the amplitude on each of the surrounding lines on which vestiges of this same pulse can be observed. Then, measure the peak and all vestiges of the next wider vertical white pulse.

Move the Line Selector to the line through the center of the widest vertical black pulse. Expand the waveform monitor display about the horizontal midpoint of this pulse.

Compare the negative-going peak amplitude, with respect to the white level, of the waveform on this line to that on adjacent lines, in order to ensure that the peak amplitude of the vertical black pulse is being observed.

Select the next narrower vertical black pulse, and observe the peak amplitude in the same manner. Continue until a pulse is found that has a peak amplitude, measured downward from the white reference level, of no more than half of the amplitude of the white reference above blanking level.

Measure the peak amplitude of the pulse found above. Also measure the amplitude on each of the surrounding lines on which vestiges of this same pulse can be observed. Then, measure the peak and all vestiges of the next wider vertical black pulse.

Repeat this entire procedure for attenuator settings of 3-dB, 6-dB, and 12-dB.

3.3.2.3 Presentation of Data

As explained in Section 3.3.1.3, all data should be converted to normalized units.

Record all of the parameter values obtained in the above procedures for horizontal and vertical transient response, for both white and black pulses, at all four attenuator settings, and for both the ATV and NTSC receiver outputs.